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APPLICATION FOR LETTERS PATENT

OF

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FOR

NON-CONTACT SAFETY SYSTEM

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CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims the benefits under 35 U.S.C. §119(e) of U.S. Provisional Application No. 60/393,180 filed July 1, 2002, entitled NON-CONTACT SAFETY SYSTEM in the name of Bearge Miller, Norman K. Miller, Michael Anderson, Kenneth Mowrer, Timothy Castello, Gary Leigh, and Raymond Sipple.

U.S. Provisional Application No. 60/393,180, filed July 1, 2002, is hereby incorporated by reference as if fully set forth herein.

FIELD OF THE INVENTION

The present invention relates to a safety system for an automatic door or gate and, more particularly, to a non-contact switch and related circuitry for use in such a safety system.

BACKGROUND OF THE INVENTION

Automatic doors that are opened and closed by an electric motor are well-known. It is desirable to have a safety system that stops or reverses the direction of travel of the door when an object is in the path of travel of the door.

Safety systems that utilize contact or pressure-activated switches located on the leading edge of an automatic door are also known in the industry. For example, U.S. Patent No. 6,396,010 to Woodward et al. discloses a safety edge switch that extends longitudinally along the

entire length of the leading edge of the door. The edge switch consists of an electrode array having a plurality of spaced apart electrically conductive bridging members. The edge switch is normally in the closed figuration. When the leading edge of the door (and thus the edge switch) engages an object, the conductive bridging members separate, thereby breaking electrical contact (in effect opening the switch) and sending a signal back to the motor that controls the door. When the motor receives this signal it reverses the direction of travel of the door.

Many of the edge or sensing switches that have been developed prior to the present invention rely on flexible covers and deformable foam located inside the flexible material. Over time, and because many doors are located outside, the weather and elements take its toll on the flexible material and the foam. In the aforementioned patent to Woodward, the switch is normally closed. If water is allowed to seep inside or if there is a deterioration of the outer flexible housing, the switch will stay closed even when the door engages an object. If the switch cannot open, no signal can be sent to the motor to reverse the direction of travel of the door which would negate the purpose of having a safety system.

Other safety systems have utilized an electric eye (i.e., light beam) system. The electric eye system is fixedly mounted on the tracks of the overhead door; a transmitter is positioned on one track while a receiver is positioned on the other track. A control circuit is usually positioned next to the door. The transmitter and receiver are located just inches off the floor.

A beam of light is transmitted from the transmitter to the receiver. If the beam of light is

interrupted (e.g., by a person walking or placing an object in the beam), the control circuit senses the interruption and sends a signal to turn the motor off or to reverse the direction of travel of the motor, thereby stopping the door from hitting the person or object that broke the beam

Some drawbacks of an electric eye system are that the transmitter and receiver are exposed. Because of the position of the transmitter and receiver proximate the ground, they are easy targets to be stepped on or kicked; at the very least, the transmitter/receiver become mis-aligned and, sometimes, are damaged. Further, a person may step over the light beam or an object may straddle the light beam without interrupting it, in which case the safety system is not triggered while the person or object is still in the path of the moving door.

U.S. Patent No. 4,984,658 to Peelle et al. discloses an optical system mounted on the door. A transmitter and a receiver are mounted on T-shaped shoes. The shoes are designed to slide in C-shaped channels. A C-shaped channel is positioned and attached on each side of the door.

In the Peelle system, the transmitter and receiver are not protected, thereby increasing the possibility that they may be bumped. Also, dirt and grime may accumulate in the exposed C-shaped channels restricting the movement of the T-shaped shoes. Finally, the length of the T-shaped shoes limit the size and type of door on which this safety system may operate. If the system is to be used for large or heavy doors, the length of the C-shaped channels and T-shaped shoes may be prohibitive because they must be long enough to compensate for the overtravel of

the door. (The "overtravel" is defined as the distance the door continues to travel after the motor controlling the movement of the door receives a signal to stop or reverse direction. The overtravel is caused by the inertia of the door.)

SUMMARY OF THE INVENTION

The present invention consists of two telescoping, spring-loaded legs – one each located along side of an automatic door. An optical sensing/detection system is located on the ends of the legs. The optical sensing system creates a light beam at a desired distance in front of the leading edge of the door. This distance is at least as great as the overtravel of the door. Before the leading edge of the door can physically engage an object, the beam is broken, a signal is sent to the controlling motor and the door either stops or reverses direction.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and form a part of the specification, illustrate the embodiments of the present invention and, together with the following description, serve to explain the principles of the invention. For the purpose of illustrating the invention, there are shown in the drawings embodiments which are presently preferred, it being understood, however, that the invention is not limited to the specific instrumentality or the precise arrangement of elements or process steps disclosed.

In the drawings:

Figure 1A is a front plan view of the safety system in accordance with the present invention mounted on a overhead door;

Figure 1B is a front plan view of the safety system illustrated in Figure 1A with the overhead door fully closed;

Figure 2A is a side view of a two-segment spring-loaded leg;

Figure 2B is a fragmentary view of an adjacent side of the spring-loaded leg illustrated in Figure 2A;

Figure 3A is a side view of the three-segment spring-loaded leg;

Figure 3B is a fragmentary view of an adjacent side of the spring-loaded leg of Figure 3A;

Figure 3C is a reduced scale view of the leg illustrated in Figure 3A;

Figure 3D is a reduced scale view of the leg illustrated in Figure 3B;

Figure 4A is a side view of a three-segment spring-loaded leg in accordance with another embodiment of the present invention;

Figure 4B is a fragmentary view of an adjacent side of the leg illustrated in Figure 4A;

Figure 5 is a flowchart of the general operations performed by the control circuit;

Figure 6 is an alternate embodiment adapted for use with elevator doors; and

Figure 7 is an alternate embodiment adapted for use with a gate.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In describing a preferred embodiment of the invention, specific terminology will be selected for the sake of clarity. However, the invention is not intended to be limited to the specific terms so selected, and it is to be understood that each specific term includes all technical equivalents that operate in a similar manner to accomplish a similar purpose.

Preferred embodiments of the present invention will now be described in detail with reference to the accompanying drawings in which the non-contact safety edge system in accordance with the present invention is generally indicated at **10**.

The present invention is designed to be used with various automatic doors and gates and is adaptable so that it may be used with almost any automatic door or gate currently sold.

In an automatic door **90**, an electric motor **92** communicates with the door via a chain or wire rope. When the motor rotates in one direction, the door moves to a fully closed position; when the motor rotates in the opposite direction, the door moves to a fully open position. The motor **92** may include a switch to stop its rotation thereby stopping the door at a position somewhere between its fully open and fully closed positions.

It is known to connect a safety system to the motor **92** that drives the door. The motor **92** either stops or reverses direction when it receives a signal from a switch or other safety circuit that senses an object in the path of travel of the door.

Referring to Figures 1A and 1B, the non-contact safety edge system **10** is illustrated in connection with a typical overhead door **90.** (In these drawings, the view is looking at the overhead door from the inside of the building.) First spring-loaded leg **12** is attached on the left side of the overhead door **90** and second spring-loaded leg **14** is attached to the right side of the door **90.** It will be apparent to those skilled in the art, after reading this detailed description, that the first and second legs may be mounted on either side of the door to accommodate a particular door or situation.

As illustrated in Figure 1A, both legs are in their fully extended position when the door **90** is fully open or partially open. When the door **90** is completely closed (i.e., the leading edge of the door engages the floor, as shown in Figure 1B) the spring-loaded legs **12, 14** are fully retracted. Depending on the actual length of the spring-loaded legs **12, 14,** the type and size of door, and the proximity of the door to the floor, the spring-loaded legs may be partially extended when the door **90** is completely closed.

As illustrated, the extension of the spring-loaded legs are substantially equal as the door moves through its entire cycle. This allows the length of the first leg **12** to remain equal to the length of the second leg **14,** throughout the entire travel of the overhead door **90.** That is, the tip **42** of the first leg remains at the same distance in front of the leading edge of the door **90** as the tip **44** of the second leg – even if the legs are partially or fully retracted.

Referring now to Figures 2A and 2B, further details of the legs are shown. Figures 2A and 2B illustrate a two-segment leg. (The right leg **14** is actually illustrated, the left leg **12** being a mirror image.)

The legs **12, 14** comprise a primary tube **16** and a secondary tube **18.** In one embodiment, both tubes **16, 18** have a square cross-section; however, it would be clear to those skilled in the art that the shape of the tube is not particularly important and tubes having a circular, rectangular or other shaped cross-section may be used.

The outer dimension of the secondary tube **18** is slightly smaller than the inner dimension of the primary tube **16.** This allows the secondary tube **18** to slide into and out of the primary tube **16** and gives the legs a telescopic ability. As the automatic door **90** rises, the secondary tube **18** relies, at least partially, on gravity to extend outward from the primary tube **16** to achieve its full length.

Slot **32** in primary tube **16** communicates with pin **33** that is attached to secondary tube **18**. This pin/slot arrangement sets the minimum and maximum travel distance of secondary tube **18** with respect to primary tube **16**.

A compression spring **20** is located within the primary tube **16** and is of sufficient diameter that it does not enter the secondary tube **18** but can abut the end of the secondary tube **18**. The opposite end of the compression spring **20** engages a pin **13**. The compression spring **20**

applies a positive pressure on the secondary tube **18** as it retracts and extends. The compression spring **20** needs only to be long enough to engage pin **13** and the end of secondary tube **18** when the door is completely closed and the legs **12**, **14** are fully retracted.

It is a feature of this invention that the secondary tube **18** is protected by the primary tube **16**. This ensures that the leg operation is smooth, resistant to dirt and other particles and virtually maintenance free. Although gravity is the primary force for keeping the legs extended and aligned, the spring(s) play an important role.

Over time, especially in industrial applications, dirt may accumulate on the secondary tube **18** and it may not slide as easily into primary tube **16**. If dirt does accumulate on the secondary tubes **18**, the springs ensure the operation of the telescoping legs by applying an initial force to move the retracted legs into their extended position.

The secondary tube **18** includes means **27** for mounting an optical system proximate the ends of each leg. The optical system comprises an optical transmitter **24** mounted on first leg **12**, an optical receiver **26** located on second leg **14**, both of which are electrically connected to an associated control circuit **28**. As illustrated, the mounting means **27** is a mounting hole through the secondary leg **18**. The hole allows wires to be threaded through the primary tube **16** and secondary tube **18** to be connected to the optical equipment.

Some embodiments of a spring-tensioned leg in accordance with the present invention

may have a reinforced section **88** in which to mount the receiver or transmitter.

An advantage of using tubes **16, 18** for the legs is that the electrical wires may be run through the middle of the legs to connect the transmitter **24** and the receiver **26** to the control circuit **28**. Also, the wires may be run through the interior of the compression springs **20** if desired. A more elaborate mounting means (including brackets, rubber holders, etc.) may be used when required.

In another embodiment, the optical transmitter and the optical receiver are both mounted on the first leg while a mirror is mounted on the second leg.

The primary tube **16** is fitted with brackets **22** as illustrated in Figure 2A, for attaching the legs to the sides of the door **90**. (The brackets **22** may take the form of L-shaped pieces as shown, or rectangular bars having multiple mounting holes or slots to allow for more flexibility in attaching the leg to the door).

A feature of the present invention is that the mounting of the legs to the door is simple and inexpensive. Usually, a ruler and a screwdriver are the only tools needed to mount the legs (and sometimes not even a ruler is required). The simplicity of the mounting means virtually eliminates the need for aligning the receiver **26** with the transmitter **28**.

Hatch marks may be placed on both leg assemblies to help with aligning the transmitter/receiver (or the tip of the legs). The hatch marks may be etched into the outer surface of the legl assemblies or may be decals.

It may be desirable to cap the tips **44** of each leg with a plastic or rubber cap (not shown) to prevent damage to the floor as the legs engage the floor. The caps may also prevent damage or scratches to an object that is struck by a leg as the door descends.

Referring again to Figures 1A and 1B, the control circuit **28** is shown mounted on the door **90**. A coiled wire **94** provides the low power voltage to operate the control circuit **28**, the transmitter **28** and the receiver **26**; the coiled wire also provides the electrical connection to allow the safety system to control the operation of the motor **92**.

The optical transmitter sends a light beam (preferably infrared) to the optical receiver. Depending on the length of the legs (i.e., the combined length of primary tube **16** and secondary tube **18**), the light beam will precede the actual leading edge of the door **90** by a pre-determined distance. In the preferred embodiment, the predetermined distance is slightly longer than the overtravel of the door.

The light beam forms a constructive leading edge in front of the physical leading edge of the door. When an object breaks the light beam, the optical receiver **26** sends a signal to the control circuit which sends the appropriate signal to the motor **92** that controls movement of the

door **90**. Depending on the situation, the motor **92** will then either stop immediately or reverse direction, thereby preventing the leading edge of the door from contacting the object. Note that even if the motor stops immediately, the inertia of the door will keep the door moving a certain distance (i.e., the overtravel).

In many industrial applications, the door is large and heavy. Once it begins moving, it has a relatively long overtravel when compared to smaller, lighter doors.

Figures 2A and 2B illustrate the basic operation of a two-segment telescoping leg. When the door **90** is open, gravity affects the secondary tubes **18** such that they are extended out from the primary tubes **16**. As the door closes and approaches the floor **95**, the tips **44** of the secondary tubes **18** engage the floor and the secondary tubes **18** retract inside the primary tubes **16**. Spring **20** provides the initial pressure to move the secondary tube **18** out from primary tube **16**. The springs and gravity continue acting on the secondary tubes until they are completely extended. This ensures the smooth deployment of secondary tubes **18** thereby ensuring that the optical transmitter in the first leg **12** remains aligned with the optical receiver in the second leg **14**.

Another feature of this invention is that the telescoping legs are not limited to two segments or sections. A three-segment, four segment, etc. telescoping leg can easily be developed. Each segment of the leg will have its own spring associated therewith. As explained

previously, the springs ensure the smooth operation of each leg segment helping ensure that the ends of the legs (and thus the light beam) are always the same distance in front of the door.

A preferred embodiment utilizing three segments for each leg, is illustrated in Figures 3A-3D. In a three-segment leg, a middle tube **17** and a secondary tube **18A** telescopically nest within primary tube **16A**. A first compression spring **20A** ensures that middle tube **17** extends properly and a second compression spring **25** mounted within secondary tube **18A** ensures that seco\ndary tube **18A** extends properly. As illustrated in Figure 3D, the second compression spring **25** is squeezed between the interior end of secondary tube **18A** and set screw **50**. Set screw **50** communicates with slot **51** in secondary tube **18A** and has a length almost the entire diameter of secondary tube **18A**.

Set screw **50** serves two purposes; first, it determines the maximum travel of secondary tube **18A** (in conjunction with slot **51**; and second, it provides a stop for compression spring **25**.

Similar to a two-segment telescoping leg, the tubes **16A, 17** in a three-segment telescoping leg also act (i.e., extend) under the pull of gravity; however the springs **20A, 25** also apply positive pressure on the telescoping tubes.

A feature of the present invention is that the legs **12, 14** are designed sufficiently long to compensate for the overtravel of almost any door. If the overtravel of the door **90** is twelve inches, the tips **44** of both legs **12, 14** should be the same distance in front of the leading edge of

the door and, in this example, this distance should be greater than twelve inches when the door **90** is completely or partially opened. Therefore, in this example, a virtual leading edge would be created about thirteen inches in front of the actual leading edge. Only when the leading edge of the door comes within twelve inches of the floor will the legs **12, 14** start to retract; however, the legs will retract in unison so that the tips of the legs will always remain the same distance before the leading edge of the door and the IR beam will not be broken as the legs retract (unless an object breaks the beam).

By designing the leg to have multiple segments, the physical profile of each leg (i.e., the primary tube **16**) may be reduced. In one embodiment, it is desired to keep the primary tube **16** under eight inches in length. However, a three-segment leg may reach almost twenty-four inches when fully extended (i.e., primary tube 16A is eight inches long, and middle tube **17** and the secondary tube **18A** are both approximately eight inches in length). This feature is important when considering the overtravel of the door. Since this safety system was designed to be used in industrial applications as well as residential applications, one size (e.g., an eight inch primary tube **16A**) will fit a majority of applications.

Similar to the function of the springs in a two-segment leg, an advantage of using compression springs is that if dirt accumulates on the primary surfaces of the telescoping tubes

17, **18A**, the springs provide positive actuation to ensure that the legs extend and retract in unison.

Another embodiment of a three-segmented leg in accordance with the present invention is illustrated in Figures 4A and 4B. This embodiment of the leg is similar to the three-segment leg illustrated in Figures 3A and 3B. The receiver or transmitter is secured to opening **27**. The middle tube **67** and the secondary tube **68** telescopically slide inside primary tube **16A**. Compression spring **20A** abuts the end of middle tube **67**. Pin 33 is attached to middle tube **67**. Slot **44** in primary tube **16A** works in conjunction with pin **33** to guide middle tube **67**. The operation of middle tube **67**, pin **33**, slot **44** and primary tube **16A** is similar to corresponding elements illustrated in Figures 2A, 2B and 3A through 3D.

Compression spring **62** is located within middle tube **67**. When leg **14C** is compressed, compression spring **62** abuts against pin **33** and the top of secondary tube **68**.

Screw guide **61** communicates with slot **51** to limit the travel of secondary tube **68**. However, screw guide **61** does not extend the diameter of secondary tube **68** but only enough to guide and prevent secondary tube **68** from sliding completely out of middle tube **67**. In this manner, secondary tube **68** may be easily removed for maintenance, repair, cleaning, or exchange by removing one relatively short screw, namely screw guide **61**.

Since the secondary tubes **68** are the smallest in diameter, they would tend to wear out quicker than the larger diameter primary tubes **16A**. Repair and/or exchange of a secondary tube **68** is a simple matter of loosening one screw (i.e., screw guide **61**), throwing the old or damaged secondary tube away, inserting a new tube and tightening the screw.

The control circuit **28** for the optical system may be mounted on the door (as illustrated in Figures 1A and 1B) or on the wall proximate the door opening. The control circuit **28** is connected to the automatic door motor **92** via wire **94**, connected to the transmitter **24** via wire **35**, and connected to the receiver **26** via wire **36**. In a preferred embodiment, the wire **94** connecting the motor **92** to the control circuit **28** is coiled to allow the wire to contract when the control circuit **28** is close to the motor and to let the wire uncoil and stretch while the control circuit **28** moves farther away from the motor. When the light beam that extends between the transmitter and the receiver is interrupted, the control circuit **28** receives a signal from the receiver; the control circuit in turn sends a signal to the motor thereby stopping the motor or reversing the motor's direction (depending on how the system is set up).

There are a number of commercially available control systems that may be used in the present invention. However, it is desirable to have a control system that reduces EMF and IR noise that may accidentally trigger the control system especially in an industrial application. In

particular, the present control system helps to reduce the number of incidents involving false positives and to increase the sensitivity of the safety system.

Figure 5 is a flow chart indicating generally the commands carried out by a control circuit in accordance with the present invention. Upon startup, the control circuit is initialized. Signals are sent to the transmitter to set then to clear the transmitter. Once the transmitter is cleared, an infrared beam is sent by the transmitter to the receiver. The transmitter periodically transmits a train of pulses. The train consists of a pre-determined number of pulses. The pulse frequency must be fairly precise. The receiver responds by pulling the signal line low for the duration of the pulse train. A microprocessor checks to see if the signal line is low, if so a counter is decremented. If the pulse train is not detected (because of a system fault or because the IR beam has been occluded) the microprocessor increments a counter. Above a certain threshold, the microprocessor treats the event as an actual object in the path of the IR beam.

Figure 6 is an alternative arrangement of the present system **10** used in connection with horizontally-moving doors as in an elevator. First door **96** and second door **97** each have their own non-contact safety system **10**. A pair of first legs **12A, 12B** and a pair of second legs **14A, 14B** are attached to the top and bottom of each door.

As illustrated in Figure 6, the length of the legs account for the overtravel of each door. The IR beams are positioned in front of the physical leading edge of the door by at least the distance of the overtravel of the door.

Figure 7 is an alternative arrangement of the present system **10** used in connection with a vertical lift gate. If an object breaks the IR beam, the gate raises.

In most embodiments, the legs of the present invention are made of steel or aluminum. However, it would be evident to one skilled in the art, after reading this description, to replace certain elements with plastic, Teflon® or graphite parts. For example, by making secondary tube **68** out of plastic (see Figures 4A and 4B), the manufacturing cost of each leg may be reduced. The selection of materials may also affect the sensitivity of the telescoping tubes. For example, Teflon or graphite tubes may more easily slide into and out of each other.

Although the leg assemblies are shown with the largest dimensioned tubes secured to the door, the transmitter/receiver attached to the smallest dimensioned tube, with the smaller dimensioned tubes moving into and out of the larger tubes, it may be desirable to have the smallest dimensioned tube connected to the door while the transmitter and receiver are attached to the largest dimensioned tubes (i.e., upside down from the leg assemblies illustrated in the attached Figures). For example, the smallest tube will be fitted with brackets **22** allowing the smallest tube to be attached to the door; the brackets may then also act as a stop to limit the telescopic nesting or distance the larger tubes slide over the smaller tubes.

Although this invention has been described and illustrated by reference to specific embodiments, it will be apparent to those skilled in the art that various changes and modifications may be made which clearly fall within the scope of this invention. The present invention is intended to be protected broadly within the spirit and scope of the appended claims.

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